METHODS OF DETERMINING MID-STROKE POSITIONS OF ACTIVE MATERIAL ACTUATED LOADS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present patent application continues in part from U.S. patent application Ser. No. 12/437,722, entitled "METHOD OF CONTROLLING A SHAPE MEMORY ALLOY ACTUATOR UTILIZING RESISTANCE CHANGE," filed on May 8, 2009, the disclosure of which is incorporated by reference herein.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates generally to methods of determining a mid-stroke position of an active material actuated load, and more particularly, to methods of determining the mid-stroke position by inducing a change in electrical resistance in the actuator through a change in the mechanical resistance to motion or otherwise modifying a circuit, correlative to the position during the stroke.

[0004] 2. Discussion of the Prior Art

[0005] Active material actuators are used in a variety of applications to translate a load between first and second generally predetermined positions corresponding to the available strain or shape memory of the material, so as to define a "stroke." In many instances, however, determining at least one mid-stroke position is also beneficial and desirous. For example, where translating a load between first and second stages of an assembly process, it may be desirous to detect when the load is midway between stages, so as to pre-initiate the second stage of the process. Conventional methods of determining mid-stroke positions of translated loads, generally include various types of position sensors and other external devices that are configured to track and/or selectively engage the load. These methods present various concerns in the art, including added mechanical complexity, higher cost, greater packing requirements, increased weight, and more components, especially where the load is large and/or cumbersome.

BRIEF SUMMARY OF THE INVENTION

[0006] Responsive to these and other concerns, the present invention recites novel methods of determining mid-stroke positions of an active material actuated load or device. The invention is useful for creating a change in electrical resistance within the material or otherwise modifying an ancillary circuit, at the mid-stroke position, so as to determine the position. The invention is useful for presenting a mid-stroke determining system that reduces the mechanical complexity, costs, packaging requirements, weight, and number of potential failure points, in comparison to prior art position determining sensors. The invention provides methods of varying the mid-stroke positions determinable, including methods of varying the locations and plurality of determinable positions. Finally, where coupled with dynamic holds or other holding mechanisms, the invention is useful for presenting a multi-position actuator that replaces for example actuators having multiple active material elements configured to provide multiple discrete displacements.

[0007] In a first aspect, the invention concerns a resistance-based method of determining a mid-stroke position of a load driven by an active material element. The element is operable to undergo a reversible change in fundamental property when exposed to or occluded from an activation signal, so as to be activated and deactivated respectively, and is operable to translate the load between first and second positions as a result of the change, thus defining a stroke. The method comprises activating or deactivating an element and monitoring the inherent electrical resistance within the element. When the load is at the mid-stroke position, a stress in the active material element is induced or reduced, so as to cause an increase or decrease in the electrical resistance correlated with the load being in a known mid-stroke position. The increase or decrease in resistance is correlated with the mid-stroke position, so as to determine the position.

[0008] In a second aspect, the invention concerns a circuit-based method of determining at least one mid-stroke position of a load driven by an active material element operable to undergo a reversible change in fundamental property when exposed to or occluded from an activation signal, and the element translates the load from between first and second positions as a result of the change, so as to define a stroke having a path. Next, an ancillary circuit is positioned relative to the path and the element is exposed to or occluded from the activation signal, so as to cause the change and translate the load. The circuit engages the load at said at least one mid-stroke position and the circuit is modified as a result of the engagement. Lastly, the modification is determined, so as to identify said at least one mid-stroke position of the load.

[0009] Further aspects of the invention include affecting (e.g., inducing or reducing) the stress in the active material element with mechanical or magnetic engagement, and modifying the circuit by selectively engaging switches, photo-interrupters, and photo-transistors. These methods are further described and exemplified by the following figures and detailed description.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

[0010] A preferred embodiment(s) of the invention is described in detail below with reference to the attached drawing figures of exemplary scale, wherein:

[0011] FIG. **1***a* is a schematic elevation of an actuation system, including an active material element in the geometric form of a wire, a portion of a load drivenly coupled with the wire and defining multiple protrusions, and a member resistively engaging the second protrusion, in accordance with a preferred embodiment of the invention;

[0012] FIG. **1***b* is a graph of electrical resistance of the active material element shown in FIG. **1***a* during a stroke, wherein the rapid changes in resistance caused by the member engaging the protrusions are circled;

[0013] FIG. **2** is a schematic elevation of an actuation system, including an active material element, a portion of a load drivenly coupled with the element and engaging a surface defining a plurality of detents, in accordance with a preferred embodiment of the invention;

[0014] FIG. **3***a* is a schematic elevation of an actuation system, including an active material element, a portion of a load drivenly coupled with the element, an external member defining a friction surface adjacent the portion, and a series of magnets or ferrous objects positioned adjacent the surface, in accordance with a preferred embodiment of the invention;

[0015] FIG. **3***b* is a schematic elevation of an actuation system, including an active material element, a portion of a